

Faculty mentoring, evidence-based assessment, and student learning: An Australian exploration of American initiatives

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ABSTRACT

There have been many improvements in Australian engineering education since the 1990s. However, given the recent drive for assuring the achievement of identified academic standards, more progress needs to be made, particularly in the area of evidence-based assessment. This paper reports on initiatives gathered from the literature and engineering academics in the USA, through an Australian National Teaching Fellowship program. The program aims to establish a process to help academics in designing and implementing evidence-based assessments that meet the needs of not only students and the staff that teach them, but also industry as well as accreditation bodies. The paper also examines the kinds and levels of support necessary for engineering academics, especially early career ones, to help meet the expectations of the current drive for assured quality and standards of both research and teaching. Academics are experiencing competing demands on their time and energy with very high expectations in research performance and increased teaching responsibilities, although many are researchers who have not had much pedagogic training. Based on the literature and investigation of relevant initiatives in the USA, we conducted interviews with several identified experts and change agents who have wrought effective academic cultural change within their institutions and beyond. These reveal that assuring the standards and quality of student learning outcomes through evidence-based assessments cannot be appropriately addressed without also addressing the issue of pedagogic training for academic staff. To be sustainable, such training needs to be complemented by a culture of on-going mentoring support from senior academics, formalised through the university administration, so that mentors are afforded resources, time, and appropriate recognition.

KEYWORDS

Mentoring academics, learning outcomes, assessment methods, evidenced learning, teaching quality.

CONTEXT

Australian universities are currently engaging with new governmental policies and regulations that require them to demonstrate enhanced quality and accountability in teaching and research. The development of national academic standards for learning outcomes in higher education is one such instance of this drive for excellence. These discipline-specific standards articulate the minimum or Threshold Learning Outcomes that a higher education institution is expected to address so that graduating students can demonstrate their achievement to their institution, accreditation agencies, and industry recruiters. This impacts not only on the design of Engineering programs (with particular emphasis on pedagogy and assessment), but also on the preparation of academics to engage with these standards and implement them in their day-to-day teaching practice.

This imperative for enhanced quality and accountability in teaching is also significant at the institutional level, for according to the Australian Bureau of Statistics, about 25 per cent of teachers in Australian universities are aged 55 and above and more than 54 per cent are aged 45 and above [1]. A number of academic institutions including the authors' home institution [2] have undertaken recruitment drives to regenerate and enrich their academic workforce by appointing capacity-building research professors and increasing the numbers of early- and mid-career academics. In engineering education, this latter group of academics faces very high expectations in research performance and increasingly substantial responsibility for producing a workforce of competent professionals. Many of these academics have relatively little teaching experience or teaching skills, and need support.

This nationally driven agenda for quality and accountability in teaching permeates also the micro level of engineering education, since the demand for enhanced academic standards and learning outcomes requires both a strong advocacy for a shift to an authentic, collaborative, outcomes-focused education and the mechanisms to support academics in transforming their professional thinking and practice. Outcomes-focused education means giving greater attention to the ways in which the curriculum design, pedagogy, assessment approaches and teaching activities can most effectively make a positive, verifiable difference to students' learning. Such education is authentic when it is couched firmly in the realities of learning environments, student and academic staff characteristics, and trustworthy educational research. That education will be richer and more efficient when academic staff work collaboratively, contributing their knowledge, experience and skills, to achieve learning outcomes based on agreed objectives.

We know that the school or departmental levels of universities are the most effective loci of changes in approaches to teaching and learning practices in higher education [3]. Heads of Schools or Departments are being increasingly entrusted with more responsibilities, in addition to setting strategic directions and managing the operational and sometimes financial aspects of their school. They are also expected to lead the development and delivery of the teaching, research and other academic activities. Guiding and mentoring individuals and groups of academics is one critical aspect of the Head of School or Department's role. Yet they do not always have the resources or support to help them mentor staff, especially the more junior academics.

In summary, the international trend in undergraduate engineering program accreditation towards demonstrable attainment of graduate attributes poses new challenges for the role of academics and the assessment of learning. This paper starts by giving the background obtained from reviewing the literature, as a foundation for the investigations. It then gives the methodology used, followed by some of the initiatives and issues identified so far. Next, a discussion of how assessment design and student learning are linked to academic staff mentoring is presented, followed by the conclusions.

BACKGROUND

It is recognized that assessment plays a critical role in influencing student approaches to learning. James, McCinnis and Devlin suggest that recognising the potent effects of assessment requirements on student study habits and capitalising on the capacity of assessment for creating preferred patterns of study, is a powerful means of reconceptualising the use of assessment [4]. In Australia, a 2010 study by David Boud and Associates confirmed that assessment plays a key role in both fostering learning and the certification of students. However, unless it first satisfies the *educational* purpose of ensuring that students can identify high quality work and can relate this knowledge to their own work, the likelihood that they will reach high standards themselves is

much reduced [5]. Based on their study, they put forward seven propositions for assessment reform in higher education as follows, by stating that assessments have the most effect when:

- assessment is used to engage students in learning that is productive.
- feedback is used to actively improve student learning.
- students and teachers become responsible partners in learning and assessment
- students are inducted into the assessment practices and cultures of higher education.
- assessment for learning is placed at the centre of subject and program design.
- assessment for learning is a focus for staff and institutional development.
- assessment provides inclusive and trustworthy representation of student achievement.

Boud and Associates [5] go on to say that the above cannot be achieved with new techniques or assessment methods, but by ensuring that what we do in assessment is always subordinated to the main goal of higher education, which is to develop educated citizens who can face the many challenges of a complex and changing society.

McAlpine [6] states that assessment must be understood, first of all, as a form of communication, primarily between student and teacher but also to employers, curriculum designers and policymakers. Assessment is thus a social function, a communications link between the education system and wider society. Taking communication as her model, McAlpine then breaks assessment down into five main points or criteria that ensure that this dialogue is worthwhile:

- clarity of purpose;
- validity/reliability;
- referencing (establishing a common measure across all candidates);
- the quality of assessment items/instruments; and
- grading, a process that relates directly to referencing.

Palmer [7] suggests also a tension between traditional forms of assessment that are simple and easy to administer (examinations, standard problem-solving etc.) and newer forms of assessment that offer a more authentic representation of practice, but could be more complex and expensive to administer. Hence, the issues around assessment cannot be examined on their own without also examining the issues around academics engaged in the teaching and learning activities.

The role of academics is reshaped by institutional and individual performance-based expectations (and funding structures). An interesting dichotomy has been created by institutions that hire academic staff to teach but give them promotion and salary advancement based primarily on their research and scholarship [8]. This creates a tension of priorities that ultimately affects the classroom and student assessments. Moreover, adjunct, part-time, casual, or contingent staff who teach part-time comprise about half the professoriate in the USA (33% in Engineering) [9], making them essential to the operation of academic programs. Many of them come from professional practice and industry and do not always have training in pedagogy or in assessment of student learning. Australia has very similar figures where the sessional staff comprise an estimated 40 to 50 per cent of all teaching in Australian higher education [10]. These issues have implications for student learning outcomes and ultimately for career pathways for future researchers and teachers.

Other engineering education issues identified in the USA are similar to those identified in Australia, albeit with different emphasis. They are: a high age profile of the academic workforce [11], a high tension between research and teaching responsibilities that often results in poor teaching and mediocre research [12], a lack of pedagogical training of new academics [13] a focus on disciplinary content at the expense of graduate capabilities in communication, argument, synthesis, evaluation, and judgement [14]; low course completion rates in the USA and Australia [15] [16] while the ever-increasing industry demand for competent graduates is not being met [17].

Pedagogical training programs tailored specifically to engineering Faculty by Teaching and Learning experts with engineering backgrounds are more likely to attract and influence larger audiences, but they require an investment that university administrators may be unwilling or unable to make. In effect, there is no tangible incentive for engineering academics to participate in instructional development to improve teaching that may result from their participation. This lack of reward for participation in pedagogic development also impacts upon the mentoring activities that senior academics might otherwise engage in with the junior academics in order to mentor them in teaching and learning [18]. It is envisaged that the development of a model for a discipline-specific academic staff development and mentoring program, might be a step towards elevating the impact of this on student learning and academic staff well-being and enhanced performance.

METHODOLOGY

The work presented in this paper has taken a specific action-research approach to educational reform known as professional practice research. This approach is defined as 'critically-informed, politically-activist and action-oriented' investigations in a range of educational settings, systemic priorities and policies and global contexts [19]. The approach is critically-informed because it situates itself within global and national trends in engineering education; politically-activist in being an agent of curriculum change; and action-oriented in involving Heads of Schools as key mentors of engineering education academics.

Following this approach, extensive evidence was gathered through one-on-one interviews with three identified experts and change agents in the USA who have wrought effective academic cultural change within their institutions and beyond. Furthermore, those experts have facilitated interviews with eight other colleagues with a wealth of breadth and depth of experiences. The specific objective was to gather evidence of curriculum initiatives and academic mentoring programs and their role in encouraging good assessment practices that provide explicit evidence of student learning by navigating a pathway between what is mandated and what will enhance student learning for professional expertise.

The findings and lessons learnt are currently being disseminated, where the Fellow is conducting mentoring and assessment workshop activities within five Australian universities through the current Fellow-in-Residence program. During his residency the Fellow will use evidence gathered from his USA visits to encourage actions leading to enhanced student learning outcomes while supporting academics.

The following reports on some of the issues and initiatives identified so far. These comprise of the insights gained from a variety of stakeholders in engineering education in the USA: a national engineering educators' association, a national engineering accreditation organisation, and Teaching and Learning leaders and Faculty from small and large universities.

ISSUES AND INITIATIVES

Although there have been systematic and impressive efforts, such as the EC2020 that have been implemented in the USA [20], some of these efforts have rarely focused on the long-term view, which is important since global competition for skilled engineers is expected to rise steadily [21]. The National Academy of Engineers (NAE) is encouraging more long-range thinking with the Engineer of 2020 initiative [22] which is an attempt to determine the kind of engineering education needed to provide graduates for careers in 2020 and beyond; it emphasises creativity, ingenuity, communication, business, leadership, ethics, professionalism, dynamism, agility, resilience, flexibility, and lifelong learning as attributes of future engineers. Because large-scale changes in engineering education take time, such efforts need to change the approach to engineering education in time to produce graduates ready for 2020 [23].

Student Learning Outcomes

The emphasis on learning outcomes is spreading throughout higher education on a global scale [25]. In engineering education, degree programme learning outcomes are becoming more commonplace as professional accreditation bodies increasingly require achievement of prescribed learning outcomes. Nevertheless, these learning outcomes may not always be made explicit to the students as they are often “hidden” in application for accreditation documentation rather than being presented to the students.

In a study of undergraduate students [24] taking a BE degree programme in Process & Chemical Engineering, students were administered a pre-survey to assess their level of knowledge of the concept of learning outcomes and of the degree programme learning outcomes themselves. Then, the contents of two documents used by the engineering program in applications for accreditation by professional accreditation bodies as well as professional Institution guidelines were reviewed to formulate the degree programme learning outcomes. These were then presented to the students for review. The same students were surveyed again. The results of the second questionnaire demonstrated a major improvement in their knowledge of both the concept of learning outcomes and of the degree programme learning outcomes [24].

This result was consistent with previous publications that discuss the advantages of articulating and communicating learning outcomes to the students. In general, it is found that learning outcomes help to explain more clearly to students what is expected of them and thus help to guide them in their studies giving them increased motivation and a sense of purpose [25] [26].

These and similar research findings worldwide have motivated universities in the USA to adopt Learning and Impact Expectation Sheets (or Learning Expectations and Learning Outcomes questionnaires) that are completed by students at the beginning of the semester. These also include a Learning Styles questionnaire that helps instructors tailor their teaching styles to include the diverse learning styles of a given cohort. They also collect information on students' expectations of the course and their needs. This is re-checked mid-semester and again at the end of the semester to determine the extent to which the expectations have been met. This form of continuous review targeting teaching impact gives the academics early clues to students' expectations and outcomes and gives them enough time to identify and change or reinforce specific teaching approaches depending on their impact [28].

Clearly, learning objectives need to be observable and measurable and the tasks set must demonstrate learning rather than specify abstract non-observable and non-measurable concepts

like "understand, know, learn, and appreciate". It is also equally important to prepare a Study Guide for the students as this process will help the academics articulate the learning objectives, connect the assessments to the learning objectives, and also give students a clear roadmap for the course and the program [27].

Mentoring

A mentor's roles comprise at least three facets: instructional, psychosocial, and role modelling [28]. Mentoring includes sponsoring a protégé, sharing sources of information and aiding in obtaining support. Ideally, then, a mentor becomes a role model of the behaviours a protégé hopes to replicate as a professional [29].

Bullard and Felder [30] offer an example of a successful engineering teaching mentorship. The academic staff member either finds or is assigned (usually by the department head) an experienced colleague to function as a teaching mentor. Formal assignment generally works better than self-selection, for several reasons. Introversions keeps many new academic staff members from asking more experienced colleagues to serve as mentors; it takes time for new academics to get to know their colleagues well enough to make a good choice; and not everyone who volunteers to be a mentor is qualified to be one. The mentor and mentee work together for a semester or academic year, perhaps co-teaching a course or periodically exchanging classroom visits and debriefing their observations afterwards [31]. Such mentorship programs also demonstrate to administrators how academic mentoring programs that assign a teaching mentor and a research mentor to new academics can decrease the time spent on their learning curve by more than half, while increasing both their research productivity and their teaching quality [33]. The success of mentoring programs is reliant on incentives and rewards for mentors, as well as top-down support, otherwise the role will not be readily adopted [32].

Assessment

Although few programs have relaxed their emphasis on foundational skills in mathematics, science, and engineering science, there is increased emphasis on nearly all of the professional skills and knowledge sets associated with ABET's EC2000 Criterion 3.a–k adopted since 1996. This also means that students have a much broader range of assessments to undertake [33]. Criterion 3 specifies 11 (hence a-k) desired student-learning outcomes to align students' educational experiences with the knowledge, skills, and dispositions defined by the a-k learning outcomes. [34] Criterion 3 maintains curricular focus on the technical knowledge base of the field (i.e., mathematics, basic science, and engineering science), but also mandates emphasis on particular professional skills. Engineering programs are expected to build students' capacity in skills such as communication and teamwork, and in knowledge areas such as professional responsibilities and ethics. Ideally, engineering curricula and instruction are expected to integrate technical and professional subject matter so that students will see relationships between those areas from the beginning of their undergraduate programs.

In response to Criteria 3.a-k, teaching methods have steadily changed over time with increased use of active learning approaches, such as group work, design projects, case studies, and application exercises, and less reliance on lecturing and textbook problems [35]. In conjunction with such alternative teaching methods, assessment practices have moved away from summative assessments to place more emphasis on formative assessments [36]. Formative assessments are built into the structure of the learning experience of the class and are typically instructive, particularly to the student, of the progress of the learning experience [37]. Formative

assessments are a vehicle for the content of the class along with other activities. Summative assessments, on the other hand, take place at the end of a unit or module and are intended to assess whether the content has been learned or not [38]. They are not intended to be part of the instructional content but rather exist to assess for grading or ranking purposes [38].

Additionally, many universities encourage real-world problem solving as opposed to theoretical knowledge with the help of several programs that aim to emulate or work with industry and community partners in engineering education.

Initiatives

Below are brief descriptions of selected initiatives undertaken by US universities to enhance student learning and support faculty. Some of these have been explored via interviews conducted with their leaders:

1. The Foundation Coalition

The National Science Foundation developed the Engineering Education Coalition program to stimulate innovative models for systemic reform of undergraduate engineering education. This enabled groups of universities to form coalitions to champion systematic change. These groups produced significant reforms that have reinvigorated undergraduate engineering curricula to produce graduates who are better prepared to meet the demands of an increasingly and rapidly changing world.

[see www.foundationcoalition.org/home/keycomponents/assessment_evaluation.html]

The goals of these coalitions included increased retention of students, especially underrepresented groups, improved learning experiences in engineering, and active experiential learning experiences.

The Foundation Coalition was one of eight engineering coalitions, and was established as an agent of systemic renewal for the engineering educational community. With its partner campuses, the Foundation Coalition has restructured its curricula [39], renovated or built new classrooms, and created faculty development projects guided by core competencies that are informed by a number of theoretical frameworks, such as social learning and constructivist learning theories that address learning and change [40]. Valuable and productive discussions with the Foundation Coalition's director, Jeff Froyd, were prompted by its particular relevance to the objectives of the fellowship program. This relevance is also demonstrated through its extensive resources which were produced to address many areas such as active and cooperative learning, student teams, technology, and assessment and evaluation.

2. Faculty Learning Communities

Another initiative of direct relevance and importance is the Faculty Learning Communities (FLC). A faculty learning community is a faculty group engaging in activities that provide learning, development, and community. Therefore, the Fellow had extensive and very informative discussions with Milton Cox at Miami University, Ohio, who pioneered and continues to lead this approach, to learn firsthand about the details of establishing and maintaining these communities.

As described in [41], the faculty learning community focuses on future, new, junior, mid-career, and senior faculty's desire for community, and support for investigation and

implementation of new teaching and learning approaches and opportunities. These communities do not focus extensively on negotiated timing or other formal structures at meetings. However, while including the efficiency of getting things done, the FLCs have more focus on the social aspects of building community. They include more emphasis on the team aspect (while still consulting about and developing each individual's project) and on the ultimate beneficiaries of the program: the students in the participants' courses and those participating as student associates of the FLC [42].

Every FLC must have clear goals and objectives. Accomplishment of these goals is usually the focus of some evaluation outcomes at mid- and end-of-year reports. As an example, the objectives of Miami's Teaching Scholars Community for Early-Career Faculty are to provide participants with support in a number of areas including:

- Information on teaching and learning
- Opportunities to observe, assess, and practice innovative teaching
- Development of syllabi articulating clear learning objectives
- Strengthening of basic teaching skills
- Clearer communication with students
- Ways to build a course around assessment of learning.
- Opportunities to share ideas and advice with faculty mentors
- Awareness of teaching as an intellectual pursuit and exploration of ways to engage in the scholarship of teaching

3. Design Clinics

Harvey Mudd College in California has used Design Clinics since the 1960s, as a capstone senior design project in conjunction with industry. Clinics are industry-sponsored projects in which a team of students works on a real-world problem of interest to the sponsoring organization. Students work in groups of four or five under the guidance of a student project manager (team leader), a Faculty advisor, and a liaison from the sponsoring organization. The sponsor's liaison outlines the project requirements, approves the team's proposal for accomplishing the work, and receives weekly progress reports. In most cases the student team visits the sponsoring company in the fall semester to learn about the technology or to give a design review to senior officials, then returns in May to present the final results. Clinic teams present their results during public forums held on-campus and submit final written reports to the sponsoring organization upon completion of the project. They are assessed jointly on a wide range of outcomes by both industry and academics based on goals set, goals achieved, group work, collaborative learning, all in a real-life setting. Sponsors retain full rights to all intellectual property developed by the team and often students get their names on to patents generated. The companies are highly interested in the outcomes of the projects and the students who work on them often end up working for these sponsors. The essential characteristics of an engineering clinic are adapted from McGlothlin [43] and detailed in Bright and Phillips [44].

- a. A teaching clinic, providing professional services.
- b. Services meet professional standards.
- c. Student participates under Faculty direction.
- d. Student's participation is organized for learning as well as providing services.
- e. Seminars or discussions are used to identify principles and procedures.
- f. Students are given increasing responsibility

This has been a long-running and highly effective initiative and its success is evidenced by the fact that they have gained hundreds of industry sponsors over the years and that keep them coming back year after year [44]. Since its inception, 1400 projects have been completed. The success of this approach has motivated its extension to a project called Global Clinic, where students undertake year-long, industry sponsored global engineering and science projects. In these projects, teams of Harvey Mudd students collaborate with teams of students from partner schools internationally with particular emphasis on partnerships in Singapore, China, India, Japan, Europe, and South America.

4. CDIO Initiative

In 2000, the Massachusetts Institute of Technology, Chalmers University of Technology, the Royal Institute of Technology, and Linköping University launched an initiative to reform engineering education [45]. A framework was established for engineering institutions to design their syllabus around real-world product, processes, and systems in a systematic way based on a complete system lifecycle, called in this approach, Conceive-Design-Implement-Operate [46]. This is contextually situated in an enterprise and social context thus training students to be more effective within real-life engineering practice. This initiative now has about 80 collaborating institutions in over 25 countries worldwide. The initiative has produced and refined a CDIO syllabus that provides a customisable template for making sure that the learning and assessment methods employed match the intended learning outcomes. These include written and oral questions, performance ratings for specific tasks, and understanding of specific concepts, product reviews, peer assessment, journaling, portfolios, self-report measures, and reflective practice. The teaching methods are evaluated and adjusted on an ongoing basis to respond to any issues identified while continuously monitoring student learning.

The above are just a small sample of the models, in the USA, that are addressing the need to assure the standard and achievement of student learning outcomes, and also support academics. They respond to the increased need for an engineering education that produces well-rounded graduates who can move smoothly from higher education to professional practice.

DISCUSSION

The drive for assuring academic standards and the achievement of student learning outcomes are the motivating factors for the work presented in this paper. However, the link between student learning outcomes, evidence-based assessment and academic staff mentoring may not be readily apparent. With the student being at the centre, our focus is on finding ways to enhance learning and provide assurance of the same to the students themselves, and also to the teaching academics.

The curriculum and assessment initiatives discussed here varied in focus from considering the whole curriculum, to addressing certain aspects of student learning, including the utilisation of assessment for learning. Although it is agreed that assessment practices have profound effects on student learning, our findings, from the interviews and the literature, reveal that the links between program objectives, course objectives and how specific assessment items can address those objectives systematically, are either missing or not made explicit. In other words, although academic staff are expected to design valid assessments - assessments that measure what it is supposed to measure - they are rarely able to make that assertion. The result is a set of assessments that are probably evaluating student attainment of outcomes that are different from

those intended. Another consequence is that, in the absence of clearly identifying the evidence required to demonstrate the achievement of specific learning outcomes, there is not sufficient thought invested into the choice of the most appropriate assessment instrument for that purpose. For example, choosing to use an exam with questions requiring students to recall information or even formulas cannot provide evidence of students' attainment of critical thinking skills. This would be true regardless of whether the course is in the first or final year of the engineering program.

With gaps such as these, either in understanding the role of assessment or the ability to design it appropriately, it would be difficult to defend claims of attainment of program objectives, academic standards, and student learning outcomes. This would be true whether that evidence is to be presented to accreditation bodies, industry, students, or to Faculty.

This highlights the need for academics to be well informed and appropriately skilled in the design of appropriate assessment techniques. Given what has been shown in this paper about the way faculty are appointed and the skill sets and abilities they bring to the university, there is need to support those academics in the area of learning and teaching. This is where faculty mentoring can play a critical role. Goos, Hughes, and Webster-Wright [47], conducted a needs identification survey, where they found that course coordinators (Program Directors) overwhelmingly expressed a desire for "personalised help" from an "academic mentor", "coach" or "guide". They subsequently developed and implemented a pilot professional development and mentoring program. They concluded that a balance between bottom-up, person-centred approach and top-down, systems-oriented approach to academic support and development is necessary in order to bring about sustainable educational reform. Through the Fellowship program, of which this current investigation is a part, the Fellow aims to work with Heads of Schools to establish and enhance mentoring programs for their Faculty.

CONCLUSION

From the experience gained from past and current national and international initiatives and from initiatives of individual organisations and academics interviewed in the USA, it is evident that a number of context-specific methods have yielded the best results in regards to student learning outcomes. Although the most effective initiatives involve academics at the coalface, they would not be as effective without the explicit and active facilitation and support from the university administration and the mentoring of junior academics by experienced teaching academics.

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